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Tree Biomass in the North Central Region

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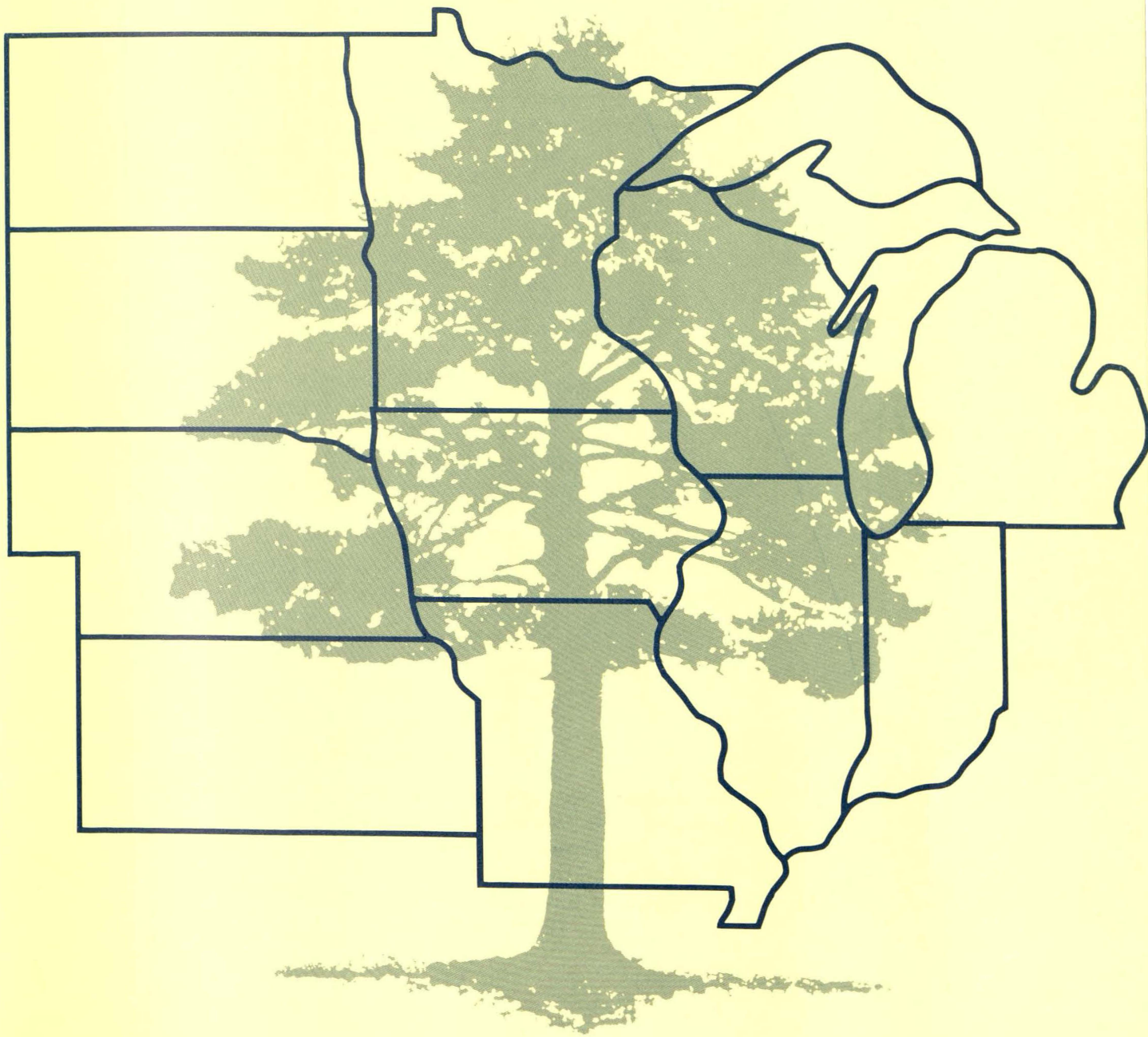

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FOREWORD

Resources Evaluation is a continuing endeavor as mandated by the Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA). Its objective is to periodically inventory the Nation's forest land to determine its extent, condition, and volume of timber, growth, and depletions. This kind of up-to-date information is essential to frame intelligent forest policies and programs. USDA Forest Service regional experiment stations are responsible for conducting these inventories and publishing summary reports for individual States. The North Central Forest Experiment Station is responsible for evaluating the forest resources of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Eastern South Dakota, and Wisconsin.

Resource bulletins analyzing findings from the most recent forest inventory are available from the Station for most north central States. Updated 1977 forest statistics for each State are found in the RPA assessment document, "An Analysis of the Timber Situation in the United States 1952-2000," available from USDA Forest Service, Washington, D.C.

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TREE BIOMASS IN THE NORTH CENTRAL REGION

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Recent changes in the Nation's forest resource picture have forced recognition of whole-tree utilization as a viable forestry practice. Increasing demand for wood fiber, increasing harvesting and production costs, and increasing interest in alternative forms of energy are just a few of the developments that have spurred interest in total aboveground tree volume.

This interest is becoming evident in the North Central Region. The Minnesota Department of Natural Resources and the Minnesota Energy Agency have released a report on the feasibility of using wood biomass for energy (Minnesota Department of Natural Resources 1980). The study concluded that in Minnesota, wood "could supply a substantial portion of the energy needed for residential heating now and in the future." A study released by the Lake Superior Basin Studies Center presents a plan for utilizing Populus species (particularly aspen) in the upper Great Lakes States (Wood 1980). The report includes an analysis of the use of aspen for food, direct combustion, gasification, and alcohol production. In a 1975-1976 study of Minnesota logging utilization factors, five logging firms were producing whole tree chips—in the previous study, dated 1960-1961, no firms had whole tree chip operations (Blyth and Smith 1980).

Until recently, timber management and wood procurement decisions could not be made on a whole tree basis because only traditional measures of merchantable volume in cubic and board feet were available. What was needed was a way to estimate the amount of wood and bark contained in the whole tree, including the crown.

A biomass committee has been formed through the Renewable Resources Evaluation (RRE) Projects at USDA Forest Service forest experiment stations to estimate aboveground tree volume (in green tons) on commercial forest land[1] nationwide using current state-of-the-art methodology.[2] This is a first step in including estimates of tree biomass in standard forest inventory efforts. The RRE Project at the North Central Forest Experiment Station estimated tree biomass on commercial forest land in 11 States—Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Eastern South Dakota, and Wisconsin. For each State, tree biomass was estimated by (1) softwoods and hardwoods and biomass component, (2) species groups and diameter class, and (3) softwoods and hardwoods and ownership class. A summary of a methodology for quantifying the biomass and estimates of the biomass for the North Central Region are presented here.

METHODS

Equations are currently available that estimate tree biomass, however, these equations were unacceptable for estimating tree biomass in the North Central Region. First, many of the equations require data unavailable for most of the north-central States. Data limitations in most States made it necessary to develop equations requiring only the number of

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[1]*Commercial forest land is forest land that is producing or is capable of producing crops of industrial wood and not withdrawn from timber utilization by statute or administrative regulation.*

[2]*Bones, James. 1980. Unpublished study plan--A plan for compiling aboveground tree biomass estimates for the United States. On file at the North Central Forest Experiment Station, Renewable Resources Evaluation Project.*

growing-stock[3] and cull[4] trees by 2-inch diameter class.

Second, some existing equations give unreliable estimates outside the range of the data used to fit the equations. For large diameter trees in particular, different equations give widely different estimates of tree biomass.

Finally, most of the existing equations do not estimate weight by components as defined by the RRE Projects. RRE estimates of tree biomass include the bark, and are made up of five components:

1. Growing-stock bole—the aboveground volume of growing-stock trees 5 inches or more in diameter from a 1-foot stump to a variable 4-inch diameter top;
2. Growing-stock top and limbs—the aboveground volume of growing-stock trees 5 inches or more in diameter from a 1-foot stump, excluding the growing-stock bole;
3. Cull tree bole—the aboveground volume of cull trees 5 inches or more in diameter from a 1-foot stump to a fixed 4-inch diameter top;
4. Cull tree top and limbs—the aboveground volume of cull trees 5 inches or more in diameter from a 1-foot stump, excluding the cull bole;
5. 1- to 5-inch trees—the total aboveground volume of all trees 1 to 5 inches in diameter.

Data available from State-wide forest inventories for estimating tree biomass vary across the Region; therefore, it is necessary to use two different methods for estimating tree biomass—one for North Dakota and Minnesota and another for all other States.

North Dakota and Minnesota: New forest inventories in North Dakota (1980) and Minnesota (1977)[5] enabled us to use gross cubic foot volume, net cubic foot volume, and bark correction factors[6] to estimate tree biomass. For each tree, the net cubic foot volume in the bole was converted to green tons using weight conversion factors for individual species (Markwardt 1930). Then, the weight of the bole bark was computed using bark correction factors for each species and an average bark weight of 37 pounds per cubic foot. The weight in the tops and limbs of growing-stock and cull trees was estimated as 45 percent of the gross bole weight (Young *et al.* 1976). Finally, the biomass for trees from 1 to 5 inches in diameter was computed by a regression equation fit to Young's tree weight table (Young *et al.* 1976). This regression equation used d.b.h. (diameter at breast height) to estimate total aboveground tree biomass as 80 percent of the total above- and belowground biomass.

All other States: Data from the 1977 Assessment for the Renewable Resources Planning Act (RPA) and the most recent State inventories were used to determine the number of growing-stock and cull trees by species group and 2-inch diameter class (USDA Forest Service 1980). For each species group in each State, biomass by component and 2-inch diameter class was computed for all trees at least 1 inch in diameter using the following equation:

$$W = A(\text{d.b.h.})^B$$

where W is the component weight in green tons per tree and A and B are regression parameters.

Nonlinear regression techniques were used with biomass data from Minnesota, North Dakota, and Wisconsin to determine the regression parameters[7] (table 1).

RESULTS

Tree biomass in the North Central Region totals 3.6 billion tons. The distribution of tree biomass among biomass components is different for softwoods and hardwoods (table 2). For softwoods, 23 percent of the total tree biomass is in from 1- to 5-inch trees, but this component accounts for only 15 percent of the total tree biomass for hardwoods (fig. 1). A larger percentage of the hardwood tree biomass is in cull trees (17 percent) than for softwoods (5 percent).

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[3]*Growing-stock trees are all live trees 1-inch d.b.h. and larger, except cull trees.*

[4]*Cull trees are rotten or rough trees. Rotten trees are live trees 1-inch d.b.h. and larger of commercial species that do not contain a merchantable 12-foot saw log, now or prospectively, because of rot. Rough trees are live trees of any size that do not contain at least one merchantable 12-foot saw log, now or prospectively, because of roughness, poor form, or noncommercial species.*

[5]*Includes 1979 data for the Superior National Forest.*

[6]*Unpublished data on file at the North Central Forest Experiment Station, Renewable Resources Evaluation Project.*

[7]*Biomass data from these three States consisted of green weight by biomass component, species group, and 2-inch diameter class. Data from the 1968 Wisconsin inventory were used for cottonwood and hemlock.*

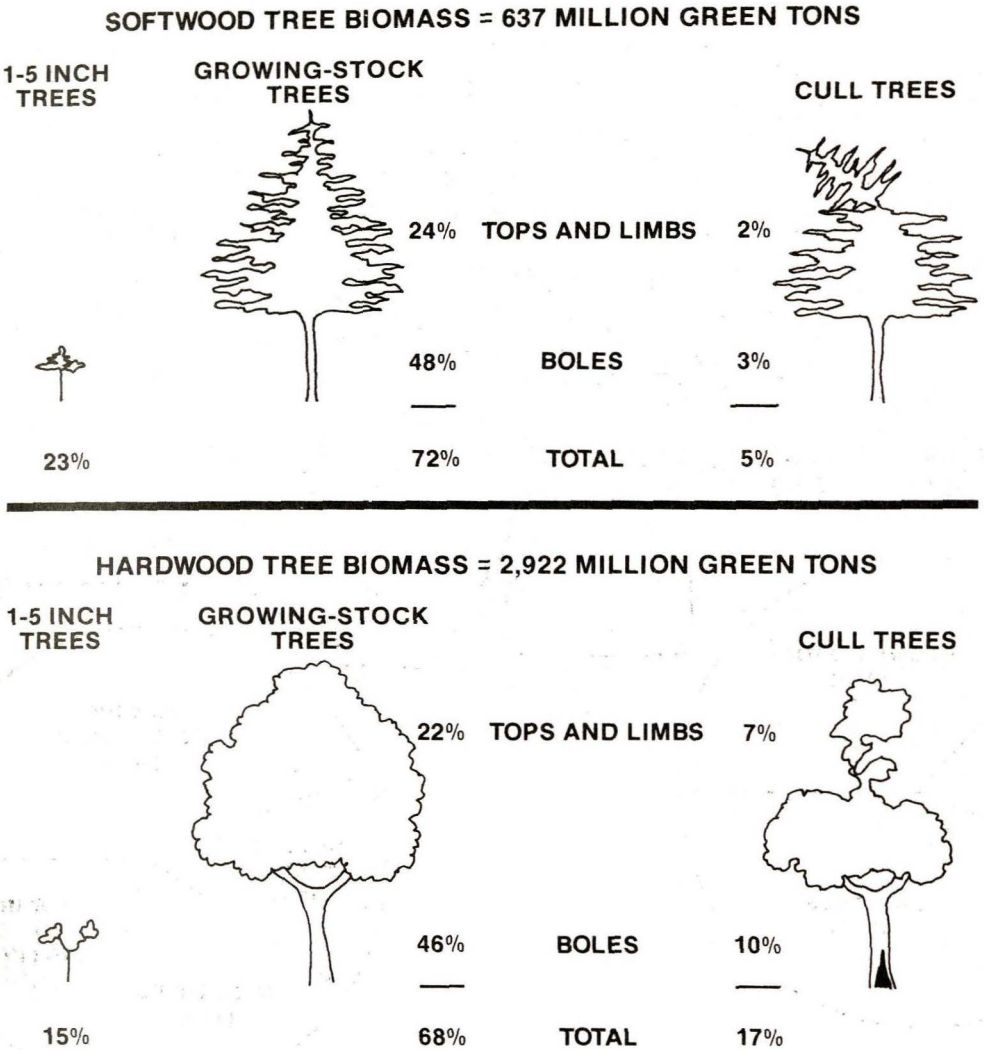

Figure 1.—*Distribution of the biomass by softwoods and hardwoods and biomass components, North Central Region.*

The distribution of tree biomass among components also varies by geographic unit (fig. 2). In the Lake States (Michigan, Minnesota, and Wisconsin), where a large portion of the region's softwood trees are found, only 12 percent of the total tree biomass is in cull trees. In the units in which hardwoods account for a large portion of the total number of trees, a larger portion of the total tree biomass is in cull trees—21 percent of the tree biomass in the Central States (Illinois, Indiana, Iowa, and Missouri) is in cull trees as is 36 percent in the Prairie States (Kansas, Nebraska, North Dakota, and Eastern South Dakota).

The average tree biomass per acre of commercial forest land in the North Central Region is 50 tons. Average tree biomass per acre by State ranges from a low of 45 tons per acre in Illinois to a high of 57 tons per acre in Indiana.

In the Central States, the oaks account for the majority of the tree biomass (table 3). Of the 1,049 million green tons found in the Unit, 303 million tons are white oaks and 276 million tons are red oaks. Softwoods total only 33 million green tons, most of which is found in loblolly and shortleaf pine species.

Although a larger portion of the tree biomass in the Lake States Unit is in softwoods than in the other units, hardwoods still make up a majority of the total. Of the 2,386 million tons of total biomass, 1,794 million are in hardwoods. Aspen and cottonwood species account for 369 million tons, hard maple for 252 million, red oak for 245 million, and birch for 243 million (table 4). Softwood tree biomass totals 591 million green tons, with balsam fir accounting for 136 million green tons and jack pine for 104 million.

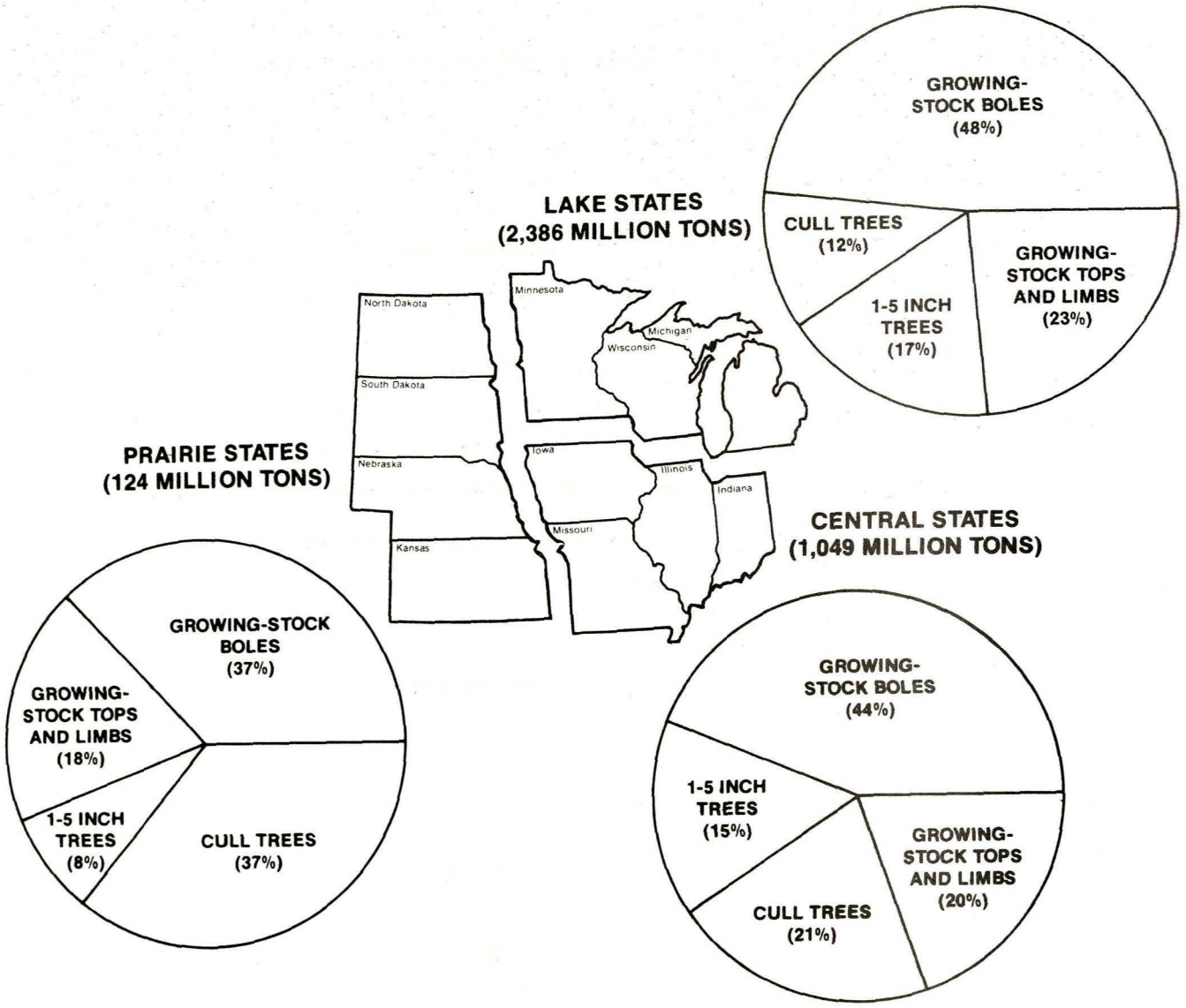

Figure 2.—*Distribution of tree biomass by biomass component and unit, North Central Region, 1978.*

Tree biomass in the Prairie States is scattered across a number of tree species with no single species accounting for a large portion of the total (table 5). The 124 million green tons found in the Unit is concentrated in hardwoods (112 million green tons). Ponderosa pine accounts for most of the softwood biomass volume.

In all units, most tree biomass is privately owned (tables 6-8). Public owners hold a larger percentage of the softwood than hardwood biomass in all units:

Ownership class	Softwood biomass	Hardwood biomass
	(Percent)	
	Central States	
Public	39	12
Private	61	88
	Lake States	
Public	47	34
Private	53	66
	Prairie States	
Public	37	6
Private	63	94

DISCUSSION

The tree biomass for each State is correlated to the tree volume, size, and species found in the State. The States with the highest growing-stock volumes per acre generally have the highest tree biomass weights per acre. Because the weight per cubic foot of wood varies widely by species group, small differences in the species composition of forests among the States can result in large differences in the total tree biomass:

Species group	Green weight of aboveground tree biomass (Pounds per cubic foot)[8]
Softwoods	
Jack pine	50
Red pine	42
Loblolly-shortleaf pine	53
White spruce	35
Black spruce	32
Balsam fir	45
Northern white-cedar	28
Other softwoods	50
Hardwoods	
White oak	62
Red oak	63
Hickory	63
Hard maple	56
Soft maple	50
Aspen-cottonwood	43
Birch	50
Other hardwoods	50

In Indiana, with the highest tree biomass per acre, red and white oaks account for 24 percent and hickory for 16 percent of the total number of growing-stock trees. Therefore, 40 percent of Indiana's trees are in the three species groups with the most dense wood. In Illinois, the species composition is similar to that found in Indiana, but the number of trees per acre of commercial forest land is so low that tree biomass per acre is the lowest in the Region.

As tree size increases linearly, weight per tree increases exponentially (fig. 3). For example, if oak diameter increases from 6 to 12 inches, the biomass per growing-stock tree increases 490 percent and the biomass per cull tree increases 590 percent. The increase in aspen and cottonwood growing-stock biomass per tree is even more dramatic. In this species group, an increase in diameter from 6 to 12 inches results in an 820 percent increase in growing-stock biomass per tree.

[8]*Adopted from L. J. Markwardt (1930).*

The RRE definitions of biomass for trees larger than 5 inches in diameter exclude a 1-foot stump. To fully calculate the aboveground biomass of a tree, the volume in the stump must be known. Raile (1981) developed a method for estimating the volume in stumps of various heights for any tree diameter. In the tabulation below, we used this method to estimate the weight of a 1-foot stump for an average softwood or hardwood growing-stock tree across a range of diameters. Stump weight is given as a percentage of the weight of the growing-stock bole:

D.b.h. (Inches)	Stump weight as a percent of the weight in the growing-stock bole	
	Softwoods	Hardwoods
6	10.2	15.8
8	9.0	12.6
10	8.2	10.7
12	7.5	9.4
14	7.0	8.5
16	6.6	7.8
18	6.3	7.2
20	6.0	6.8
22	5.8	6.5
24	5.6	6.1
26	5.4	5.9
28	5.2	5.7
30	5.1	5.5

For example, the weight of a 1-foot stump for a 6-inch d.b.h. hardwood growing-stock tree is 15.8 percent of the bole biomass.

Estimates of tree biomass can be used in conjunction with timber removals data to estimate the amount of wood left in forests after conventional logging operations. In 1976, growing-stock removals from commercial forest land in the North Central Region totaled 1,109 million cubic feet—195 million cubic feet from softwoods and 916 million cubic feet from hardwoods. Of this total, only 54 percent was used for products:

Item	1976 growing-stock removals	
	Softwoods	Hardwoods
	(Million cubic feet)	
Products	152	554
Logging residue	4	57
Other removals[9]	39	305
	195	916

The 706 million cubic feet used for products is equal to 22 million green tons. By definition growing-stock removals come only from the boles of grow-

[9]*Other removals are (1) growing-stock volumes removed during land clearing and timber stand improvement work but not utilized for products, and (2) volumes lost as a result of changes in land use.*

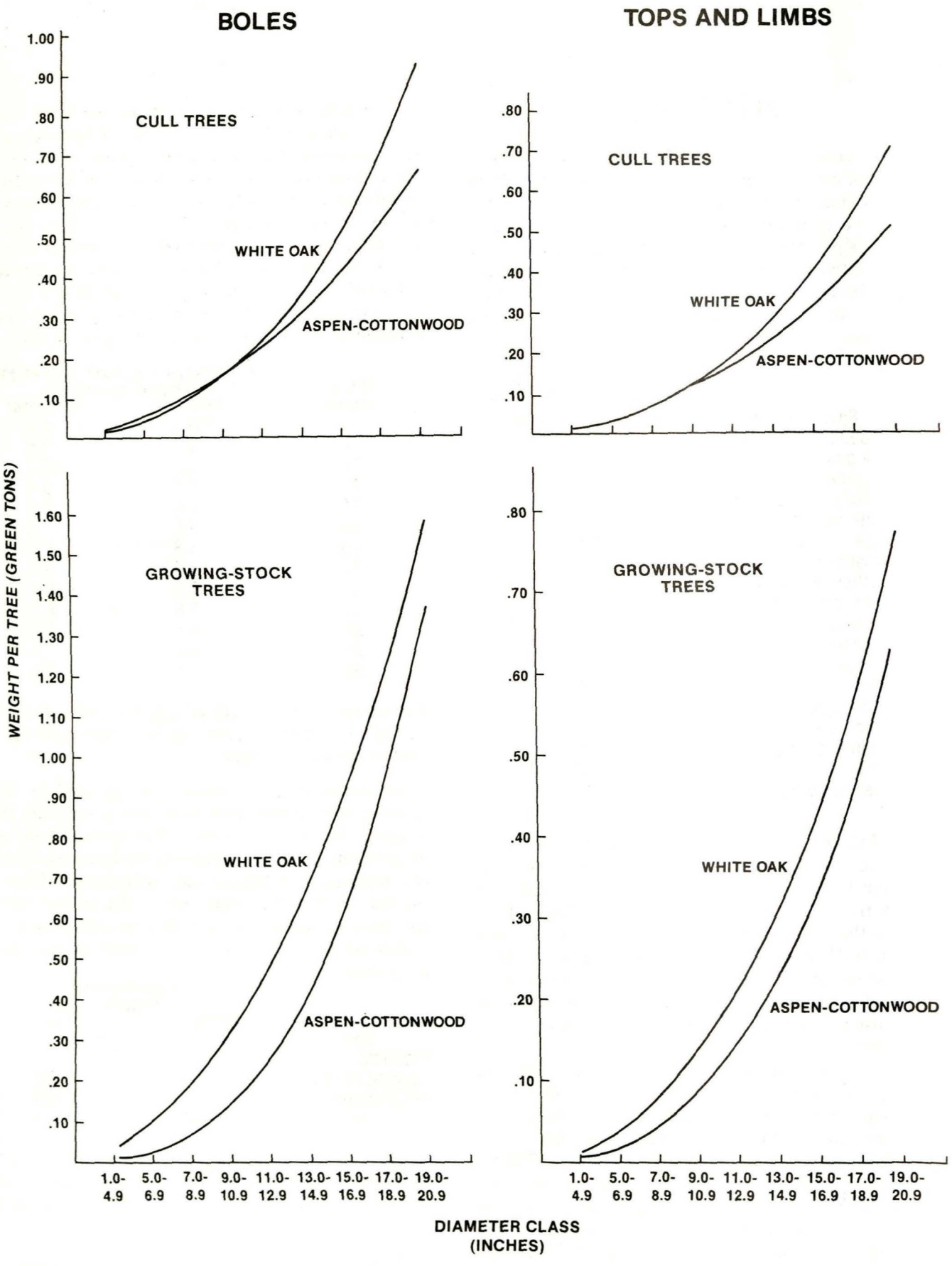

Figure 3.—*Green weight per tree by diameter class and biomass component, white oak and aspen-cottonwood, North Central Region.*

ing-stock trees, and boles account for an average of 68 percent of the total growing-stock tree biomass. This means that on the average, 32 percent of the total tree biomass is left in forests following harvest.

In the North Central Region in 1976 an estimated 10 million green tons of tops and limbs were left following removal of the growing-stock boles for products. In addition, more than 2 million green tons of logging residue were left. Logging residue is unused portions of the bole from cut growing-stock trees plus unused growing-stock trees killed by logging. Therefore, 12 million green tons of tree biomass are available for energy production or new forest products without jeopardizing current supplies.

As mentioned earlier, many opportunities exist for using tree biomass to help alleviate some of the Nation's energy problems: burning wood provides an alternative way to heat homes and buildings or generate electricity, wood-derived chemicals can be used as petroleum substitutes, and wood products can be substituted for energy-intensive metals and plastics. Current use of woody biomass for energy is about 1.3 quads,[10] or 2 percent of the Nation's energy budget. By 1990, energy from woody biomass could be 6.4 quads, or about 8 percent of the Nation's energy budget (USDA Forest Service 1980).

The amount of energy available per pound of wood is fairly consistent across species groups. Wood at 20 percent moisture content produces approximately 6,400 Btu's per pound of wood (Agricultural Extension Service 1979). However, the energy available per unit volume of wood varies because species that are more dense have more pounds of wood per unit volume. The available heat units (in million Btu's per cord of 90 solid cubic feet) of wood and bark are shown below for several north-central species (Hendricks 1974).

Species	Air-dry[11]	Green
	(Million Btu's per 90 solid cubic feet)	
Red pine	17.8	16.8
White pine	14.2	12.9
Hemlock	15.0	12.8
White oak	23.9	22.4
Red oak	21.7	19.6
Hickory	24.8	23.1
Aspen	14.1	12.2
Paper birch	18.2	16.7
Elm	17.7	15.8

[10]*One quad = 1.0 X 10^{15} British Thermal Units (Btu's).*

[11]*From 15 to 20 percent moisture.*

The energy content of tree biomass in the North Central Region is 26.3 x 10^{15} Btu's. Hardwoods account for 80 percent of the energy potential. The energy content of the 12 million green tons of unused tops and limbs and logging residue is approximately 92.4 X 10^{12} Btu's.

SUMMARY

The estimates of tree biomass presented here are a first step toward estimating total woody biomass on commercial forest land. The next step will entail estimating woody biomass in the forest understory. Methods for calculating biomass of the major north-central shrub species are currently being refined and evaluated by Project scientists. The Project anticipates using the method described above to estimate tree biomass as part of the standard forest inventory in each State.

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Table 1.--Biomass equation parameters

Species	Biomass Component							
	Growing stock				Cull			
	Boles		Tops and limbs		Boles		Tops and limbs	
	A	B	A	B	A	B	A	B
	x 10^{-3}		x 10^{-3}		x 10^{-3}		x 10^{-3}	
Jack pine	1.959	2.1457	.453	2.4197	.646	2.2562	.720	2.2633
Red pine 1/	1.453	2.2749	1.410	2.0285	1.844	1.8345	2.083	1.8429
White pine	.539	2.5895	.132	2.8060	.077	3.0459	.059	3.0415
White spruce	.392	2.6898	.236	2.6177	.118	2.7082	.153	2.7497
Black spruce	.190	2.8971	.197	2.7108	.316	2.3167	.074	3.0300
Balsam fir	.706	2.5404	.266	2.6321	.001	4.5421	.002	4.5427
Hemlock	.337	2.7915	.225	2.6652	.093	2.9225	.099	2.9265
Tamarack	.650	2.5857	.668	2.3282	.031	3.3055	.042	3.3107
Northern white-cedar	.384	2.5461	.138	2.7198	.134	2.6150	.146	2.6229
Other softwoods	1.066	2.3170	1.336	1.8396	.184	2.7407	.148	2.7578
Select white oak	1.996	2.2276	.485	2.4591	.419	2.5684	.320	2.5687
Select red oak	1.451	2.3582	.443	2.5155	.468	2.5535	.363	2.5537
Select hickory	5.274	1.8599	1.940	1.9741	.221	2.8099	.176	2.8005
Beech	2.476	2.1046	.600	2.3265	.109	2.9984	.078	2.9991
Hard maple	.792	2.5477	.365	2.5440	.736	2.3281	.582	2.3264
Soft maple	1.072	2.3888	.459	2.4164	1.124	2.1090	.139	2.7753
Ash	.926	2.3419	.269	2.6291	.117	2.1310	.930	2.1301
Aspen-cottonwood	.119	3.1213	.110	2.9053	1.150	2.1194	.876	2.1207
Birch	4.294	1.8932	.383	2.5301	1.084	2.2015	.807	2.1970
Yellow poplar	2.424	2.1077	.609	2.3201	5.725	1.6789	.322	1.6273
Other hardwoods	1.147	2.3659	.407	2.4564	.942	2.2122	.749	2.2100

1/ Red pine parameters were used for ponderosa and loblolly-shortleaf pine species groups.

Table 2.--Total green weight of aboveground tree biomass on commercial forest land by State, softwoods and hardwoods, biomass component, and Unit

(In thousand green tons)

State	All components	Biomass component				
		1"-5" trees	Growing-stock		Cull	
			Boles	Tops and limbs	Boles	Tops and limbs
CENTRAL STATES						
Illinois						
Softwoods	2,138	509	900	486	117	126
Hardwoods	165,103	14,963	89,865	41,052	10,852	8,371
Total	167,241	15,472	90,765	41,538	10,969	8,497
Indiana						
Softwoods	4,924	1,280	2,299	1,073	145	127
Hardwoods	210,971	25,705	110,232	50,700	13,815	10,519
Total	215,895	26,985	112,531	51,773	13,960	10,646
Iowa						
Softwoods	578	147	206	91	72	62
Hardwoods	75,354	8,882	34,060	15,624	9,434	7,354
Total	75,932	9,029	34,266	15,715	9,506	7,416
Missouri						
Softwoods	25,585	5,822	11,978	6,488	678	619
Hardwoods	564,485	99,865	216,260	95,349	86,272	66,739
Total	590,070	105,687	228,238	101,837	86,950	67,358
Unit totals						
Softwoods	33,225	7,758	15,383	8,138	1,012	934
Hardwoods	1,015,913	149,415	450,417	202,725	120,373	92,983
Total	1,049,138	157,173	465,800	210,863	121,385	93,917
LAKE STATES						
Michigan						
Softwoods	252,569	55,039	125,432	61,417	5,114	5,567
Hardwoods	777,988	126,717	390,202	178,209	47,134	35,726
Total	1,030,557	181,756	515,634	239,626	52,248	41,293
Minnesota						
Softwoods	183,475	56,047	80,160	38,436	5,231	3,601
Hardwoods	477,442	79,469	222,086	108,571	38,897	28,419
Total	660,917	135,516	302,246	147,007	44,128	32,020
Wisconsin						
Softwoods	155,333	26,005	82,461	39,297	3,691	3,879
Hardwoods	538,839	69,529	256,050	115,316	55,615	42,329
Total	694,172	95,534	338,511	154,613	59,306	46,208
Unit totals						
Softwoods	591,377	137,091	288,053	139,150	14,036	13,047
Hardwoods	1,794,269	275,715	868,338	402,096	141,646	106,474
Total	2,385,646	412,806	1,156,391	541,246	155,682	119,521
PRAIRIE STATES						
Kansas						
Softwoods	90	13	15	7	31	24
Hardwoods	58,126	5,628	17,799	8,270	14,834	11,595
Total	58,216	5,641	17,814	8,277	14,865	11,619
Nebraska						
Softwoods	10,279	662	5,908	3,149	260	300
Hardwoods	28,487	616	11,835	5,707	5,819	4,510
Total	38,766	1,278	17,743	8,856	6,079	4,810
North Dakota						
Softwoods	72	6	43	19	3	1
Hardwoods	15,903	2,720	5,979	2,841	2,763	1,600
Total	15,975	2,726	6,022	2,860	2,766	1,601
South Dakota						
Softwoods	1,886	252	964	545	59	66
Hardwoods	9,637	479	3,858	1,906	1,908	1,486
Total	11,523	731	4,822	2,451	1,967	1,552
Unit totals						
Softwoods	12,327	933	6,930	3,720	353	391
Hardwoods	112,153	9,443	39,471	18,724	25,324	19,191
Total	124,480	10,376	46,401	22,444	25,677	19,582

Table 3.--Total green weight of aboveground tree biomass on commercial forest land by species group, diameter, class and biomass component, Central States

(In thousand green tons)

Species group	All components	Biomass component			
		Growing-stock		Cull	
		Boles	Tops and limbs	Boles	Tops and limbs
LOBLOLLY-SHORTLEAF PINE					
1.0" - 4.9"	4,038	1,823	1,309	423	483
5.0" - 6.9"	3,875	2,196	1,371	143	165
7.0" - 8.9"	4,807	2,955	1,719	61	72
9.0" - 10.9"	4,193	2,671	1,470	24	28
11.0" - 12.9"	3,145	2,037	1,072	17	19
13.0" - 14.9"	1,314	855	433	12	14
15.0" - 16.9"	447	300	147	--	--
17.0" - 18.9"	251	165	78	4	4
19.0" - 20.9"	67	42	20	2	3
21.0" - 28.9"	--	--	--	--	--
29.0" - over	--	--	--	--	--
Total	22,137	13,044	7,619	686	788
OTHER SOFTWOODS					
1.0" - 4.9"	3,720	1,995	1,457	147	121
5.0" - 6.9"	1,965	1,096	584	156	129
7.0" - 8.9"	1,858	1,077	501	152	128
9.0" - 10.9"	1,419	764	319	183	153
11.0" - 12.9"	891	481	184	123	103
13.0" - 14.9"	483	283	100	54	46
15.0" - 16.9"	302	178	59	35	30
17.0" - 18.9"	127	86	27	7	7
19.0" - 20.9"	75	31	10	19	15
21.0" - 28.9"	128	93	25	5	5
29.0" - over	120	73	19	15	13
Total	11,088	6,157	3,285	896	750
TOTAL SOFTWOODS					
1.0" - 4.9"	7,758	3,818	2,766	570	604
5.0" - 6.9"	5,840	3,292	1,955	299	294
7.0" - 8.9"	6,665	4,032	2,220	213	200
9.0' - 10.9"	5,612	3,435	1,789	207	181
11.0" - 12.9"	4,036	2,518	1,256	140	122
13.0" - 14.9"	1,797	1,138	533	66	60
15.0" - 16.9"	749	478	206	35	30
17.0" - 18.9"	378	251	105	11	11
19.0" - 20.9"	142	73	30	21	18
21.0" - 28.9"	128	93	25	5	5
29.0" - over	120	73	19	15	13
Total	33,225	19,201	10,904	1,582	1,538
WHITE OAK					
1.0" - 4.9"	33,186	18,381	5,955	5,016	3,834
5.0" - 6.9"	33,821	19,625	7,221	3,952	3,023
7.0" - 8.9"	38,889	22,685	8,921	4,126	3,157
9.0" - 10.9"	42,520	23,383	9,684	5,356	4,097
11.0" - 12.9"	40,296	21,407	9,248	5,463	4,178
13.0" - 14.9"	39,213	20,527	9,190	5,380	4,116
15.0" - 16.9"	26,992	13,154	6,073	4,399	3,366
17.0" - 18.9"	17,279	7,870	3,734	3,215	2,460
19.0" - 20.9"	11,042	4,439	2,159	2,518	1,926
21.0" - 28.9"	16,728	5,676	2,878	4,631	3,543
29.0" - over	3,017	1,044	553	804	616
Total	302,983	158,191	65,616	44,860	34,316
RED OAK					
1.0" - 4.9"	24,384	13,277	4,914	3,488	2,705
5.0" - 6.9"	23,917	13,235	5,358	2,998	2,326
7.0" - 8.9"	31,822	17,357	7,351	4,006	3,108
9.0" - 10.9"	39,539	21,129	9,269	5,147	3,994
11.0" - 12.9"	37,678	19,600	8,848	5,197	4,033
13.0" - 14.9"	33,062	17,155	7,934	4,489	3,484
15.0" - 16.9"	27,002	13,425	6,341	4,074	3,162
17.0" - 18.9"	19,389	9,319	4,485	3,145	2,440
19.0" - 20.9"	13,994	6,269	3,066	2,623	2,036
21.0" - 28.9"	21,994	8,990	4,526	4,773	3,705
29.0" - over	3,522	1,089	565	1,052	816
Total	276,303	140,845	62,657	40,992	31,809

(Table 3 continued on next page)

(Table 3 continued)

Species group	All components	Biomass component: Growing-stock: Boles	Biomass component: Growing-stock: Tops and limbs	Biomass component: Cull: Boles	Biomass component: Cull: Tops and limbs
HICKORY					
1.0" - 4.9"	41,200	25,712	10,794	2,627	2,067
5.0" - 6.9"	25,745	16,005	7,223	1,413	1,104
7.0" - 8.9"	22,348	13,465	6,280	1,463	1,140
9.0" - 10.9"	19,289	11,305	5,408	1,449	1,127
11.0" - 12.9"	13,684	7,720	3,772	1,234	958
13.0" - 14.9"	9,409	5,388	2,678	756	587
15.0" - 16.9"	6,161	3,442	1,737	554	428
17.0" - 18.9"	3,433	1,827	936	377	293
19.0" - 20.9"	1,647	836	433	213	165
21.0" - 28.9"	1,589	762	403	239	185
29.0" - over	150	67	35	27	21
Total	144,655	86,529	39,699	10,352	8,075
HARD MAPLE					
1.0" - 4.9"	3,470	1,826	838	450	356
5.0" - 6.9"	3,228	1,897	868	259	204
7.0" - 8.9"	3,555	2,012	921	348	274
9.0" - 10.9"	3,687	2,106	963	346	272
11.0" - 12.9"	3,068	1,707	780	325	256
13.0" - 14.9"	3,570	1,955	893	404	318
15.0" - 16.9"	2,851	1,584	723	305	239
17.0" - 18.9"	2,095	1,022	466	340	267
19.0" - 20.9"	1,321	621	283	234	183
21.0" - 28.9"	2,068	796	363	509	400
29.0" - over	222	42	20	90	70
Total	29,135	15,568	7,118	3,610	2,839
SOFT MAPLE					
1.0" - 4.9"	2,961	1,253	553	913	242
5.0" - 6.9"	2,479	1,329	597	393	160
7.0" - 8.9"	2,858	1,576	714	380	188
9.0" - 10.9"	3,065	1,722	786	354	203
11.0" - 12.9"	3,389	1,851	848	419	271
13.0" - 14.9"	3,153	1,831	843	279	200
15.0" - 16.9"	2,485	1,377	636	265	207
17.0" - 18.9"	1,697	912	424	195	166
19.0" - 20.9"	1,425	756	352	166	151
21.0" - 28.9"	3,487	1,677	783	506	521
29.0" - over	1,277	570	269	203	235
Total	28,276	14,854	6,805	4,073	2,544
ASH					
1.0" - 4.9"	5,243	1,679	688	1,604	1,272
5.0" - 6.9"	4,660	2,131	1,035	834	660
7.0" - 8.9"	4,678	2,219	1,171	719	569
9.0" - 10.9"	4,111	1,976	1,111	572	452
11.0" - 12.9"	3,583	1,733	1,028	458	364
13.0" - 14.9"	2,548	1,240	768	301	239
15.0" - 16.9"	1,868	963	619	160	126
17.0" - 18.9"	1,391	651	434	171	135
19.0" - 20.9"	843	364	250	128	101
21.0" - 28.9"	1,250	512	371	205	162
29.0" - over	146	52	40	30	24
Total	30,321	13,520	7,515	5,182	4,104
BIRCH					
1.0" - 4.9"	235	96	20	69	50
5.0" - 6.9"	424	260	72	53	39
7.0" - 8.9"	317	210	70	21	16
9.0" - 10.9"	316	199	77	23	17
11.0" - 12.9"	285	160	70	32	23
13.0" - 14.9"	439	196	94	86	63
15.0" - 16.9"	218	104	54	34	26
17.0" - 18.9"	167	70	40	33	24
19.0" - 20.9"	93	43	26	14	10
21.0" - 28.9"	167	63	43	35	26
29.0" - over	60	18	13	17	12
Total	2,721	1,419	579	417	306

(Table 3 continued on next page)

(Table 3 continued)

Species group	All components	Biomass component: Growing-stock: Boles	Biomass component: Growing-stock: Tops and limbs	Biomass component: Cull: Boles	Biomass component: Cull: Tops and limbs
ASPEN-COTTONWOOD					
1.0" - 4.9"	581	114	80	220	167
5.0" - 6.9"	544	225	141	101	77
7.0" - 8.9"	674	317	187	96	74
9.0" - 10.9"	845	458	257	74	56
11.0" - 12.9"	1,005	568	306	74	57
13.0" - 14.9"	963	587	306	40	30
15.0" - 16.9"	963	611	308	25	19
17.0" - 18.9"	1,222	759	375	50	38
19.0" - 20.9"	1,344	819	396	73	56
21.0" - 28.9"	4,053	2,516	1,167	210	160
29.0" - over	1,163	699	312	86	66
Total	13,357	7,673	3,835	1,049	800
BEECH					
1.0" - 4.9"	394	268	84	24	18
5.0" - 6.9"	381	234	85	36	26
7.0" - 8.9"	613	382	147	49	35
9.0" - 10.9"	620	361	146	66	47
11.0" - 12.9"	662	381	161	70	50
13.0" - 14.9"	767	497	217	31	22
15.0" - 16.9"	971	531	238	118	84
17.0" - 18.9"	1,227	573	263	228	163
19.0" - 20.9"	740	347	164	133	96
21.0" - 28.9"	2,111	567	278	737	529
29.0" - over	726	95	49	339	243
Total	9,212	4,236	1,832	1,831	1,313
YELLOW-POPLAR					
1.0" - 4.9"	1,275	748	239	188	100
5.0" - 6.9"	962	598	220	95	49
7.0" - 8.9"	1,070	729	284	38	19
9.0" - 10.9"	1,143	772	317	36	18
11.0" - 12.9"	1,311	849	361	68	33
13.0" - 14.9"	1,451	971	428	35	17
15.0" - 16.9"	948	614	278	38	18
17.0" - 18.9"	876	543	252	55	26
19.0" - 20.9"	576	376	179	14	7
21.0" - 28.9"	828	480	237	75	36
29.0" - over	100	33	17	34	16
Total	10,540	6,713	2,812	676	339
OTHER HARDWOODS					
1.0" - 4.9"	36,486	8,968	3,550	13,364	10,604
5.0" - 6.9"	23,008	9,563	3,988	5,277	4,180
7.0" - 8.9"	22,078	10,701	4,579	3,794	3,004
9.0" - 10.9"	19,763	10,186	4,449	2,863	2,265
11.0" - 12.9"	16,061	8,199	3,641	2,357	1,864
13.0" - 14.9"	14,036	7,301	3,287	1,925	1,523
15.0" - 16.9"	11,513	5,948	2,710	1,595	1,260
17.0" - 18.9"	7,850	3,969	1,827	1,147	907
19.0" - 20.9"	5,451	2,564	1,192	947	748
21.0" - 28.9"	9,794	4,604	2,177	1,684	1,329
29.0" - over	2,370	1,188	572	341	269
Total	168,410	73,191	31,972	35,294	27,953
TOTAL HARDWOODS					
1.0" - 4.9"	149,415	72,322	27,715	27,963	21,415
5.0" - 6.9"	119,169	65,102	26,808	15,411	11,848
7.0" - 8.9"	128,902	71,653	30,625	15,040	11,584
9.0" - 10.9"	134,898	73,597	32,467	16,286	12,548
11.0" - 12.9"	121,022	64,175	29,063	15,697	12,087
13.0" - 14.9"	108,611	57,648	26,638	13,726	10,599
15.0" - 16.9"	81,972	41,753	19,717	11,567	8,935
17.0" - 18.9"	56,626	27,515	13,236	8,956	6,919
19.0" - 20.9"	38,476	17,434	8,500	7,063	5,479
21.0" - 28.9"	64,069	26,643	13,226	13,604	10,596
29.0" - over	12,753	4,897	2,445	3,023	2,388
Total	1,015,913	522,739	230,440	148,336	114,398
All species	1,049,138	541,940	241,344	149,918	115,936

Table 4.--Total green weight of aboveground tree biomass on commercial forest land by species group, diameter class, and biomass component, Lake States

(In thousand green tons)

Species group	All components	Biomass component: Growing-stock: Boles	Biomass component: Growing-stock: Tops and limbs	Biomass component: Cull: Boles	Biomass component: Cull: Tops and limbs
JACK PINE					
1.0" - 4.9"	24,570	17,016	5,711	983	860
5.0" - 6.9"	26,286	17,781	7,076	698	731
7.0" - 8.9"	25,683	17,010	7,218	728	727
9.0" - 10.9"	15,625	9,931	4,394	661	639
11.0" - 12.9"	7,611	4,864	2,211	282	254
13.0" - 14.9"	3,083	1,894	881	159	149
15.0" - 16.9"	1,043	614	292	77	60
17.0" - 18.9"	302	152	75	47	28
19.0" - 20.9"	55	21	11	13	10
21.0" - 28.9"	34	23	11	--	--
29.0" - over	--	--	--	--	--
Total	104,292	69,306	27,880	3,648	3,458
RED PINE					
1.0" - 4.9"	13,444	7,604	5,280	271	289
5.0" - 6.9"	11,531	6,914	4,225	190	202
7.0" - 8.9"	8,544	5,319	2,978	123	124
9.0" - 10.9"	6,285	3,950	2,049	144	142
11.0" - 12.9"	5,924	3,793	1,917	102	112
13.0" - 14.9"	6,109	3,963	1,962	88	96
15.0" - 16.9"	5,365	3,542	1,718	48	57
17.0" - 18.9"	4,326	2,877	1,366	40	43
19.0" - 20.9"	2,307	1,538	716	26	27
21.0" - 28.9"	2,311	1,574	704	16	17
29.0" - over	15	9	4	1	1
Total	66,161	41,083	22,919	1,049	1,110
WHITE PINE					
1.0" - 4.9"	1,851	1,260	425	108	58
5.0" - 6.9"	2,002	1,350	501	92	59
7.0" - 8.9"	2,829	1,852	727	146	104
9.0" - 10.9"	4,033	2,661	1,090	165	117
11.0" - 12.9"	5,422	3,518	1,496	238	170
13.0" - 14.9"	5,652	3,711	1,625	182	134
15.0" - 16.9"	5,733	3,699	1,663	213	158
17.0" - 18.9"	5,428	3,488	1,605	192	143
19.0" - 20.9"	4,126	2,643	1,244	136	103
21.0" - 28.9"	7,803	4,738	2,334	415	316
29.0" - over	1,201	730	378	52	41
Total	46,080	29,650	13,088	1,939	1,403
WHITE SPRUCE					
1.0" - 4.9"	3,718	2,347	1,206	100	65
5.0" - 6.9"	3,337	2,119	1,120	48	50
7.0" - 8.9"	4,272	2,733	1,404	62	73
9.0" - 10.9"	3,647	2,305	1,159	79	104
11.0" - 12.9"	2,891	1,844	912	59	76
13.0" - 14.9"	2,183	1,401	689	38	55
15.0" - 16.9"	1,466	953	463	21	29
17.0" - 18.9"	704	454	220	13	17
19.0" - 20.9"	418	274	132	5	7
21.0" - 28.9"	370	241	116	5	8
29.0" - over	--	--	--	--	--
Total	23,006	14,671	7,421	430	484
BLACK SPRUCE					
1.0" - 4.9"	23,568	13,969	7,262	1,596	741
5.0" - 6.9"	13,309	8,176	4,632	289	212
7.0" - 8.9"	8,636	5,325	2,986	179	146
9.0" - 10.9"	3,404	2,059	1,154	103	88
11.0" - 12.9"	1,032	620	345	35	32
13.0" - 14.9"	422	249	141	17	15
15.0" - 16.9"	249	149	85	7	8
17.0" - 18.9"	113	68	39	2	4
19.0" - 20.9"	19	12	7	--	--
21.0" - 28.9"	2	1	1	--	--
29.0" - over	3	--	--	1	2
Total	50,757	30,628	16,652	2,229	1,248

(Table 4 continued on next page)

(Table 4 continued)

Species group	All components	Biomass component: Growing-stock Boles	Biomass component: Growing-stock Tops and limbs	Biomass component: Cull Boles	Biomass component: Cull Tops and limbs
BALSAM FIR					
1.0" - 4.9"	42,799	28,353	12,367	1,418	661
5.0" - 6.9"	36,204	24,302	11,056	533	313
7.0" - 8.9"	29,788	19,945	9,171	382	290
9.0" - 10.9"	16,720	10,936	5,097	355	332
11.0" - 12.9"	6,971	4,506	2,139	162	164
13.0" - 14.9"	2,294	1,462	701	64	67
15.0" - 16.9"	802	500	243	28	31
17.0" - 18.9"	290	153	73	28	36
19.0" - 20.9"	53	32	16	2	3
21.0" - 28.9"	10	7	3	--	--
29.0" - over	--	--	--	--	--
Total	135,931	90,196	40,866	2,972	1,897
HEMLOCK					
1.0" - 4.9"	1,519	934	535	24	26
5.0" - 6.9"	1,950	1,214	647	43	46
7.0" - 8.9"	3,948	2,456	1,264	110	118
9.0" - 10.9"	6,871	4,189	2,096	282	304
11.0" - 12.9"	8,089	5,013	2,452	300	324
13.0" - 14.9"	8,274	5,212	2,499	271	292
15.0" - 16.9"	7,338	4,643	2,190	243	262
17.0" - 18.9"	5,125	3,256	1,512	172	185
19.0" - 20.9"	3,803	2,449	1,122	112	120
21.0" - 28.9"	6,667	4,261	1,909	239	258
29.0" - over	397	256	112	14	15
Total	53,981	33,883	16,338	1,810	1,950
TAMARACK					
1.0" - 4.9"	8,808	5,040	2,928	566	274
5.0" - 6.9"	8,572	5,019	2,972	334	247
7.0" - 8.9"	6,606	3,973	2,219	231	183
9.0" - 10.9"	3,203	1,924	1,020	135	124
11.0" - 12.9"	1,617	969	498	76	74
13.0" - 14.9"	648	376	191	39	42
15.0" - 16.9"	246	149	75	11	11
17.0" - 18.9"	127	72	35	11	9
19.0" - 20.9"	22	12	6	2	2
21.0" - 28.9"	3	2	1	--	--
29.0" - over	--	--	--	--	--
Total	29,852	17,536	9,945	1,405	966
NORTHERN WHITE-CEDAR					
1.0" - 4.9"	16,380	10,370	4,636	860	514
5.0" - 6.9"	14,453	8,931	4,425	563	534
7.0" - 8.9"	16,206	9,755	5,005	739	707
9.0" - 10.9"	13,480	7,681	4,051	892	856
11.0" - 12.9"	8,197	4,545	2,461	607	584
13.0" - 14.9"	5,024	2,797	1,551	339	337
15.0" - 16.9"	2,811	1,541	877	197	196
17.0" - 18.9"	1,564	859	501	98	106
19.0" - 20.9"	893	488	290	55	60
21.0" - 28.9"	1,252	686	428	64	74
29.0" - over	42	22	15	2	3
Total	80,302	47,675	24,240	4,416	3,971
OTHER SOFTWOODS					
1.0" - 4.9"	434	214	127	61	32
5.0" - 6.9"	173	96	50	14	13
7.0" - 8.9"	174	100	48	14	12
9.0" - 10.9"	84	48	22	9	5
11.0" - 12.9"	114	69	28	9	8
13.0" - 14.9"	15	3	2	6	4
15.0" - 16.9"	9	2	1	4	2
17.0" - 18.9"	3	--	--	2	1
19.0" - 20.9"	6	--	--	4	2
21.0" - 28.9"	3	--	--	2	1
29.0" - over	--	--	--	--	--
Total	1,015	532	278	125	80

(Table 4 continued on next page)

(Table 4 continued)

Species group	All components	Biomass component: Growing-stock: Boles	Biomass component: Growing-stock: Tops and limbs	Biomass component: Cull: Boles	Biomass component: Cull: Tops and limbs
TOTAL SOFTWOODS					
1.0" - 4.9"	137,091	87,107	40,477	5,987	3,520
5.0" - 6.9"	117,817	75,902	36,704	2,804	2,407
7.0" - 8.9"	106,686	68,468	33,020	2,714	2,484
9.0" - 10.9"	73,352	45,684	22,132	2,825	2,711
11.0" - 12.9"	47,868	29,741	14,459	1,870	1,798
13.0" - 14.9"	33,704	21,068	10,242	1,203	1,191
15.0" - 16.9"	25,062	15,792	7,607	849	814
17.0" - 18.9"	17,982	11,379	5,426	605	572
19.0" - 20.9"	11,702	7,469	3,544	355	334
21.0" - 28.9"	18,455	11,533	5,507	741	674
29.0" - over	1,658	1,017	509	70	62
Total	591,377	375,160	179,627	20,023	16,567
WHITE OAK					
1.0" - 4.9"	11,425	7,225	2,561	1,007	632
5.0" - 6.9"	11,326	7,126	2,765	817	618
7.0" - 8.9"	13,591	8,272	3,365	1,119	835
9.0" - 10.9"	13,436	7,859	3,344	1,281	952
11.0" - 12.9"	13,691	7,524	3,326	1,637	1,204
13.0" - 14.9"	12,805	6,750	3,082	1,705	1,268
15.0" - 16.9"	9,835	4,984	2,352	1,435	1,064
17.0" - 18.9"	6,607	3,125	1,521	1,121	840
19.0" - 20.9"	4,551	1,974	990	905	682
21.0" - 28.9"	7,237	2,731	1,421	1,764	1,321
29.0" - over	1,323	431	232	370	290
Total	105,827	58,001	24,959	13,161	9,706
RED OAK					
1.0" - 4.9"	17,520	10,668	4,015	1,640	1,197
5.0" - 6.9"	23,937	14,305	5,849	2,134	1,649
7.0" - 8.9"	33,273	19,975	8,533	2,695	2,070
9.0" - 10.9"	36,093	21,336	9,416	3,025	2,316
11.0" - 12.9"	31,849	17,926	8,152	3,272	2,499
13.0" - 14.9"	30,058	16,681	7,779	3,166	2,432
15.0" - 16.9"	22,983	12,486	5,961	2,560	1,976
17.0" - 18.9"	15,589	8,047	3,931	2,037	1,574
19.0" - 20.9"	12,543	6,172	3,058	1,860	1,453
21.0" - 28.9"	18,990	8,525	4,357	3,425	2,683
29.0" - over	1,954	740	394	451	369
Total	244,789	136,861	61,445	26,265	20,218
HICKORY					
1.0" - 4.9"	3,519	2,347	988	108	76
5.0" - 6.9"	2,980	1,956	879	81	64
7.0" - 8.9"	2,950	1,892	878	101	79
9.0" - 10.9"	3,538	2,158	1,028	198	154
11.0" - 12.9"	1,878	1,119	541	123	95
13.0" - 14.9"	1,584	895	441	140	108
15.0" - 16.9"	878	464	232	102	80
17.0" - 18.9"	228	126	64	21	17
19.0" - 20.9"	352	166	85	57	44
21.0" - 28.9"	245	99	52	53	41
29.0" - over	--	--	--	--	--
Total	18,152	11,222	5,188	984	758
HARD MAPLE					
1.0" - 4.9"	42,371	24,333	11,159	3,982	2,897
5.0" - 6.9"	37,894	22,837	10,541	2,516	2,000
7.0" - 8.9"	32,053	19,315	8,880	2,167	1,691
9.0" - 10.9"	29,048	17,359	7,964	2,104	1,621
11.0" - 12.9"	24,992	14,273	6,546	2,358	1,815
13.0" - 14.9"	24,777	14,162	6,489	2,331	1,795
15.0" - 16.9"	20,501	11,688	5,356	1,947	1,510
17.0" - 18.9"	16,043	9,078	4,158	1,585	1,222
19.0" - 20.9"	10,225	5,016	2,295	1,634	1,280
21.0" - 28.9"	13,075	6,542	2,994	1,981	1,558
29.0" - over	864	391	178	165	130
Total	251,843	144,994	66,560	22,770	17,519

(Table 4 continued on next page)

(Table 4 continued)

Species group	All components	Biomass component: Growing-stock: Boles	Biomass component: Growing-stock: Tops and limbs	Biomass component: Cull: Boles	Biomass component: Cull: Tops and limbs
SOFT MAPLE					
1.0" - 4.9"	35,458	20,424	9,074	4,585	1,375
5.0" - 6.9"	27,822	16,824	7,718	2,223	1,057
7.0" - 8.9"	23,561	14,092	6,449	1,961	1,059
9.0" - 10.9"	18,967	11,378	5,210	1,492	887
11.0" - 12.9"	13,571	7,905	3,633	1,224	809
13.0" - 14.9"	11,647	6,737	3,108	1,045	757
15.0" - 16.9"	6,702	3,706	1,718	720	558
17.0" - 18.9"	4,600	2,473	1,149	534	444
19.0" - 20.9"	3,086	1,488	694	477	427
21.0" - 28.9"	4,312	2,066	969	640	637
29.0" - over	1,060	407	194	228	231
Total	150,786	87,500	39,916	15,129	8,241
ASH					
1.0" - 4.9"	19,283	10,918	4,707	2,204	1,454
5.0" - 6.9"	16,600	9,702	4,860	1,138	900
7.0" - 8.9"	17,094	10,106	5,256	971	761
9.0" - 10.9"	13,215	7,658	4,114	817	626
11.0" - 12.9"	9,110	5,050	2,827	706	527
13.0" - 14.9"	5,854	3,174	1,858	464	358
15.0" - 16.9"	3,627	1,934	1,161	301	231
17.0" - 18.9"	1,525	782	498	135	110
19.0" - 20.9"	801	384	243	95	79
21.0" - 28.9"	1,297	566	401	180	150
29.0" - over	92	33	23	17	19
Total	88,498	50,307	25,948	7,028	5,215
BIRCH					
1.0" - 4.9"	54,135	38,483	9,597	3,728	2,327
5.0" - 6.9"	55,162	37,322	12,435	3,171	2,234
7.0" - 8.9"	50,175	32,549	12,411	3,132	2,083
9.0" - 10.9"	34,499	21,696	8,979	2,306	1,518
11.0" - 12.9"	20,101	11,586	5,153	1,993	1,369
13.0" - 14.9"	10,170	5,339	2,549	1,327	955
15.0" - 16.9"	6,618	3,440	1,765	817	596
17.0" - 18.9"	4,013	1,942	1,075	569	427
19.0" - 20.9"	3,079	1,169	693	695	522
21.0" - 28.9"	4,248	1,455	974	1,040	779
29.0" - over	627	202	154	157	114
Total	242,827	155,183	55,785	18,935	12,924
ASPEN-COTTONWOOD					
1.0" - 4.9"	51,803	24,473	13,176	8,767	5,387
5.0" - 6.9"	56,571	29,400	16,775	5,846	4,550
7.0" - 8.9"	75,110	40,980	21,846	7,066	5,218
9.0" - 10.9"	70,684	39,044	20,038	6,718	4,884
11.0" - 12.9"	54,810	29,917	15,172	5,613	4,108
13.0" - 14.9"	32,399	17,235	8,673	3,697	2,794
15.0" - 16.9"	14,953	7,589	3,804	2,005	1,555
17.0" - 18.9"	6,272	2,682	1,503	1,140	947
19.0" - 20.9"	3,206	1,396	664	621	525
21.0" - 28.9"	2,615	1,320	499	431	365
29.0" - over	258	149	66	23	20
Total	368,681	194,185	102,216	41,927	30,353
BEECH					
1.0" - 4.9"	3,316	2,463	777	44	32
5.0" - 6.9"	2,785	1,971	711	60	43
7.0" - 8.9"	2,658	1,838	707	66	47
9.0" - 10.9"	3,122	2,113	854	90	65
11.0" - 12.9"	3,755	2,353	991	239	172
13.0" - 14.9"	3,557	2,151	937	273	196
15.0" - 16.9"	4,030	2,367	1,062	350	251
17.0" - 18.9"	3,086	1,725	794	330	237
19.0" - 20.9"	1,936	828	390	418	300
21.0" - 28.9"	2,472	1,055	519	523	375
29.0" - over	23	9	5	5	4
Total	30,740	18,873	7,747	2,398	1,722

(Table 4 continued on next page)

(Table 4 continued)

YELLOW-POPLAR

Species group	All components	Biomass component			
		Growing-stock		Cull	
		Boles	Tops and limbs	Boles	Tops and limbs
1.0" - 4.9"	53	32	10	7	4
5.0" - 6.9"	42	26	10	4	2
7.0" - 8.9"	29	19	7	2	1
9.0" - 10.9"	30	19	8	2	1
11.0" - 12.9"	30	18	8	3	1
13.0" - 14.9"	25	15	7	2	1
15.0" - 16.9"	76	44	20	8	4
17.0" - 18.9"	24	14	6	3	1
19.0" - 20.9"	--	--	--	--	--
21.0" - 28.9"	126	61	30	24	11
29.0" - over	--	--	--	--	--
Total	435	248	106	55	26
		OTHER HARDWOODS			
1.0" - 4.9"	36,832	16,234	6,641	8,355	5,602
5.0" - 6.9"	30,196	17,497	7,636	2,813	2,250
7.0" - 8.9"	57,629	36,394	15,882	2,982	2,371
9.0" - 10.9"	51,282	32,641	14,451	2,344	1,846
11.0" - 12.9"	30,052	17,791	8,016	2,359	1,886
13.0" - 14.9"	26,673	15,642	7,111	2,182	1,738
15.0" - 16.9"	18,668	10,901	5,014	1,519	1,234
17.0" - 18.9"	12,889	7,382	3,433	1,151	923
19.0" - 20.9"	8,663	4,642	2,183	1,023	815
21.0" - 28.9"	15,268	7,835	3,752	2,053	1,628
29.0" - over	3,539	1,605	812	640	482
Total	291,691	168,564	74,931	27,421	20,775
		TOTAL HARDWOODS			
1.0" - 4.9"	275,715	157,600	62,705	34,427	20,983
5.0" - 6.9"	265,315	158,966	70,179	20,803	15,367
7.0" - 8.9"	308,123	185,432	84,214	22,262	16,215
9.0" - 10.9"	273,914	163,261	75,406	20,377	14,870
11.0" - 12.9"	203,839	115,462	54,365	19,527	14,485
13.0" - 14.9"	159,549	88,781	42,034	16,332	12,402
15.0" - 16.9"	108,871	59,603	28,445	11,764	9,059
17.0" - 18.9"	70,876	37,376	18,132	8,626	6,742
19.0" - 20.9"	48,442	23,235	11,295	7,785	6,127
21.0" - 28.9"	69,885	32,255	15,968	12,114	9,548
29.0" - over	9,740	3,967	2,058	2,056	1,659
Total	1,794,269	1,025,938	464,801	176,073	127,457
All species	2,385,646	1,401,098	644,428	196,096	144,024

Table 5.--Total green weight of aboveground tree biomass on commercial forest land by species group, diameter, class and biomass component, Prairie States

(In thousand green tons)

Species group	All components	Biomass component: Growing-stock: Boles	Biomass component: Growing-stock: Tops and limbs	Biomass component: Cull: Boles	Biomass component: Cull: Tops and limbs
JACK PINE					
1.0" - 4.9"	4	3	1	--	--
5.0" - 6.9"	37	27	10	--	--
7.0" - 8.9"	59	40	17	1	1
9.0" - 10.9"	17	12	5	--	--
11.0" - 12.9"	--	--	--	--	--
13.0" - 14.9"	--	--	--	--	--
15.0" - 16.9"	--	--	--	--	--
17.0" - 18.9"	--	--	--	--	--
19.0" - 20.9"	--	--	--	--	--
21.0" - 28.9"	--	--	--	--	--
29.0" - over	--	--	--	--	--
Total	117	82	33	1	1
PONDEROSA PINE					
1.0" - 4.9"	893	390	275	107	121
5.0" - 6.9"	1,285	760	471	25	29
7.0" - 8.9"	1,900	1,142	662	46	50
9.0" - 10.9"	2,178	1,353	744	38	43
11.0" - 12.9"	2,032	1,279	673	37	43
13.0" - 14.9"	1,778	1,038	526	99	115
15.0" - 16.9"	924	570	279	35	40
17.0" - 18.9"	468	265	126	36	41
19.0" - 20.9"	245	167	78	--	--
21.0" - 28.9"	72	50	22	--	--
29.0" - over	--	--	--	--	--
Total	11,775	7,014	3,856	423	482
OTHER SOFTWOODS					
1.0" - 4.9"	36	16	11	5	4
5.0" - 6.9"	164	100	53	6	5
7.0" - 8.9"	85	47	22	9	7
9.0" - 10.9"	59	38	16	3	2
11.0" - 12.9"	48	29	11	4	4
13.0" - 14.9"	16	8	3	3	2
15.0" - 16.9"	9	5	2	1	1
17.0" - 18.9"	1	--	--	1	--
19.0" - 20.9"	2	--	--	1	1
21.0" - 28.9"	8	--	--	4	4
29.0" - over	7	--	--	4	3
Total	435	243	118	41	33
TOTAL SOFTWOODS					
1.0" - 4.9"	933	409	287	112	125
5.0" - 6.9"	1,486	887	534	31	34
7.0" - 8.9"	2,044	1,229	701	56	58
9.0" - 10.9"	2,254	1,403	765	41	45
11.0" - 12.9"	2,080	1,308	684	41	47
13.0" - 14.9"	1,794	1,046	529	102	117
15.0" - 16.9"	933	575	281	36	41
17.0" - 18.9"	469	265	126	37	41
19.0" - 20.9"	247	167	78	1	1
21.0" - 28.9"	80	50	22	4	4
29.0" - over	7	--	--	4	3
Total	12,327	7,339	4,007	465	516
WHITE OAK					
1.0" - 4.9"	1,414	552	218	385	259
5.0" - 6.9"	1,598	666	255	397	280
7.0" - 8.9"	2,105	889	367	494	355
9.0" - 10.9"	2,141	883	383	511	364
11.0" - 12.9"	1,949	849	372	423	305
13.0" - 14.9"	1,672	682	309	391	290
15.0" - 16.9"	1,169	479	223	268	199
17.0" - 18.9"	1,079	439	208	247	185
19.0" - 20.9"	907	364	176	209	158
21.0" - 28.9"	1,753	437	221	621	474
29.0" - over	405	58	31	179	137
Total	16,192	6,298	2,763	4,125	3,006

(Table 5 continued on next page)

(Table 5 continued)

Species group	All components	Biomass component: Growing-stock: Boles	Biomass component: Growing-stock: Tops and limbs	Biomass component: Cull: Boles	Biomass component: Cull: Tops and limbs
RED OAK					
1.0" - 4.9"	319	126	47	82	64
5.0" - 6.9"	445	208	84	86	67
7.0" - 8.9"	523	255	108	90	70
9.0" - 10.9"	501	222	97	102	80
11.0" - 12.9"	615	334	151	73	57
13.0" - 14.9"	620	325	150	81	64
15.0" - 16.9"	556	276	131	84	65
17.0" - 18.9"	480	231	111	78	60
19.0" - 20.9"	403	195	96	63	49
21.0" - 28.9"	588	201	101	161	125
29.0" - over	77	--	--	43	34
Total	5,127	2,373	1,076	943	735
HICKORY					
1.0" - 4.9"	297	175	74	27	21
5.0" - 6.9"	483	295	133	31	24
7.0" - 8.9"	484	282	131	40	31
9.0" - 10.9"	362	187	90	48	37
11.0" - 12.9"	284	142	69	41	32
13.0" - 14.9"	194	91	45	33	25
15.0" - 16.9"	205	103	52	28	22
17.0" - 18.9"	122	50	26	26	20
19.0" - 20.9"	155	54	28	41	32
21.0" - 28.9"	234	54	29	85	66
29.0" - over	41	--	--	23	18
Total	2,861	1,433	677	423	328
HARD MAPLE					
1.0" - 4.9"	20	8	3	5	4
5.0" - 6.9"	41	20	9	7	5
7.0" - 8.9"	47	27	12	4	4
9.0" - 10.9"	39	17	8	8	6
11.0" - 12.9"	25	13	6	3	3
13.0" - 14.9"	40	24	11	3	2
15.0" - 16.9"	26	15	7	2	2
17.0" - 18.9"	3	--	--	2	1
19.0" - 20.9"	3	--	--	2	1
21.0" - 28.9"	15	3	1	6	5
29.0" - over	3	--	--	2	1
Total	262	127	57	44	34
SOFT MAPLE					
1.0" - 4.9"	94	14	7	57	16
5.0" - 6.9"	74	8	4	44	18
7.0" - 8.9"	109	29	13	45	22
9.0" - 10.9"	147	51	23	46	27
11.0" - 12.9"	119	46	21	32	20
13.0" - 14.9"	118	47	22	29	20
15.0" - 16.9"	76	27	13	20	16
17.0" - 18.9"	150	69	32	27	22
19.0" - 20.9"	76	33	15	15	13
21.0" - 28.9"	162	47	22	46	47
29.0" - over	24	--	--	11	13
Total	1,149	371	172	372	234
ASH					
1.0" - 4.9"	1,242	424	187	379	252
5.0" - 6.9"	1,384	548	263	327	246
7.0" - 8.9"	1,429	518	265	376	270
9.0" - 10.9"	1,650	595	322	423	310
11.0" - 12.9"	1,489	599	337	319	234
13.0" - 14.9"	1,592	579	343	380	290
15.0" - 16.9"	1,176	441	275	259	201
17.0" - 18.9"	705	260	163	158	124
19.0" - 20.9"	455	172	108	98	77
21.0" - 28.9"	582	123	85	210	164
29.0" - over	114	14	11	50	39
Total	11,818	4,273	2,359	2,979	2,207

(Table 5 continued on next page)

(Table 5 continued)

Species group	All components	Growing-stock Boles	Growing-stock Tops and limbs	Cull Boles	Cull Tops and limbs
		BIRCH			
		Biomass component			
1.0" - 4.9"	48	31	14	2	1
5.0" - 6.9"	89	54	26	6	3
7.0" - 8.9"	85	43	20	15	7
9.0" - 10.9"	45	26	12	4	3
11.0" - 12.9"	52	35	17	--	--
13.0" - 14.9"	32	12	6	9	5
15.0" - 16.9"	--	--	--	--	--
17.0" - 18.9"	--	--	--	--	--
19.0" - 20.9"	--	--	--	--	--
21.0" - 28.9"	--	--	--	--	--
29.0" - over	--	--	--	--	--
Total	351	201	95	36	19
		ASPEN-COTTONWOOD			
1.0" - 4.9"	1,800	738	357	420	285
5.0" - 6.9"	1,821	744	385	403	289
7.0" - 8.9"	2,455	1,008	518	533	396
9.0" - 10.9"	2,590	1,046	536	575	433
11.0" - 12.9"	2,424	968	508	543	405
13.0" - 14.9"	2,265	876	452	530	407
15.0" - 16.9"	1,828	770	391	378	289
17.0" - 18.9"	1,857	793	390	385	289
19.0" - 20.9"	1,978	987	477	291	223
21.0" - 28.9"	6,419	3,242	1,511	946	720
29.0" - over	2,230	993	448	454	335
Total	27,667	12,165	5,973	5,458	4,071
		OTHER HARDWOODS			
1.0" - 4.9"	4,209	847	345	1,706	1,311
5.0" - 6.9"	4,172	1,183	496	1,402	1,091
7.0" - 8.9"	4,964	1,560	671	1,546	1,187
9.0" - 10.9"	5,081	1,590	701	1,576	1,214
11.0" - 12.9"	5,056	1,867	835	1,340	1,014
13.0" - 14.9"	5,084	1,902	862	1,316	1,004
15.0" - 16.9"	4,448	1,739	801	1,082	826
17.0" - 18.9"	3,625	1,367	634	918	706
19.0" - 20.9"	2,773	1,079	506	670	518
21.0" - 28.9"	6,114	1,826	865	1,932	1,491
29.0" - over	1,200	185	88	519	408
Total	46,726	15,145	6,804	14,007	10,770
		TOTAL HARDWOODS			
1.0" - 4.9"	9,443	2,915	1,252	3,063	2,213
5.0" - 6.9"	10,107	3,726	1,655	2,703	2,023
7.0" - 8.9"	12,201	4,611	2,105	3,143	2,342
9.0" - 10.9"	12,556	4,617	2,172	3,293	2,474
11.0" - 12.9"	12,013	4,853	2,316	2,774	2,070
13.0" - 14.9"	11,617	4,538	2,200	2,772	2,107
15.0" - 16.9"	9,484	3,850	1,893	2,121	1,620
17.0" - 18.9"	8,021	3,209	1,564	1,841	1,407
19.0" - 20.9"	6,750	2,884	1,406	1,389	1,071
21.0" - 28.9"	15,867	5,933	2,835	4,007	3,092
29.0" - over	4,094	1,250	578	1,281	985
Total	112,153	42,386	19,976	28,387	21,404
All species	124,480	49,725	23,983	28,852	21,920

Table 6.--Total green weight of aboveground tree biomass on commercial forest land by ownership class, softwoods and hardwoods, and biomass component, Central States

(In thousand green tons)

Ownership class	All components	Biomass component				
		1"-5" trees	Growing-stock		Cull	
			Boles	Tops and limbs	Boles	Tops and limbs
National Forest						
Softwoods	11,368	755	6,386	3,431	410	386
Hardwoods	83,204	13,408	34,445	15,344	11,285	8,722
Total	94,572	14,163	40,831	18,775	11,695	9,108
Other public						
Softwoods	1,741	256	919	458	57	51
Hardwoods	40,941	5,258	18,980	8,607	4,568	3,528
Total	42,682	5,514	19,899	9,065	4,625	3,579
Forest Industry						
Softwoods	1,479	268	727	392	47	45
Hardwoods	18,988	4,710	6,877	3,056	2,450	1,895
Total	20,467	4,978	7,604	3,448	2,497	1,940
Other private						
Softwoods	18,637	6,479	7,351	3,857	498	452
Hardwoods	872,780	126,039	390,115	175,718	102,070	78,838
Total	891,417	132,518	397,466	179,575	102,568	79,290
All owners						
Softwoods	33,225	7,758	15,383	8,138	1,012	934
Hardwoods	1,015,913	149,415	450,417	202,725	120,373	92,983
Total	1,049,138	157,173	465,800	210,863	121,385	93,917

Table 7.--Total green weight of aboveground tree biomass on commercial forest land by ownership class, softwoods and hardwoods, and biomass component, Lake States

(In thousand green tons)

Ownership class	All components	Biomass component				
		1"-5" trees	Growing-stock		Cull	
			Boles	Tops and limbs	Boles	Tops and limbs
National Forest						
Softwoods	94,914	15,878	50,623	24,293	2,112	2,008
Hardwoods	172,943	26,436	84,361	38,522	13,666	9,958
Total	267,857	42,314	134,984	62,815	15,778	11,966
Other public						
Softwoods	184,824	49,653	85,040	41,087	4,900	4,144
Hardwoods	433,618	69,430	207,647	97,316	33,840	25,385
Total	618,442	119,083	292,687	138,403	38,740	29,529
Forest Industry						
Softwoods	82,997	15,340	42,949	20,787	1,963	1,958
Hardwoods	172,963	24,176	85,748	39,288	13,525	10,226
Total	255,960	39,516	128,697	60,075	15,488	12,184
Other private						
Softwoods	228,642	56,220	109,441	52,983	5,061	4,937
Hardwoods	1,014,745	155,673	490,582	226,970	80,615	60,905
Total	1,243,387	211,893	600,023	279,953	85,676	65,842
All owners						
Softwoods	591,377	137,091	288,053	139,150	14,036	13,047
Hardwoods	1,794,269	275,715	868,338	402,096	141,646	106,474
Total	2,385,646	412,806	1,156,391	541,246	155,682	119,521

Table 8.--Total green weight of aboveground tree biomass on commercial forest land by ownership class, softwoods and hardwoods, and biomass component, Prairie States

(In thousand green tons)

Ownership class	All components	Biomass component				
		1"-5" trees	Growing-stock		Cull	
			Boles	Tops and limbs	Boles	Tops and limbs
National Forest						
Softwoods	2,449	65	1,465	780	65	74
Hardwoods	164	107	20	9	19	9
Total	2,613	172	1,485	789	84	83
Other public						
Softwoods	2,128	139	1,185	660	68	76
Hardwoods	6,244	509	2,338	1,116	1,286	995
Total	8,372	648	3,523	1,776	1,354	1,071
Forest Industry						
Softwoods	--	--	--	--	--	--
Hardwoods	--	--	--	--	--	--
Total	--	--	--	--	--	--
Other private						
Softwoods	7,750	729	4,280	2,280	220	241
Hardwoods	105,745	8,827	37,113	17,599	24,019	18,187
Total	113,495	9,556	41,393	19,879	24,239	18,428
All owners						
Softwoods	12,327	933	6,930	3,720	353	391
Hardwoods	112,153	9,443	39,471	18,724	25,324	19,191
Total	124,480	10,376	46,401	22,444	25,677	19,582

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Tree biomass in the North Central Region. Res. Pap. NC-220. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1982. 22 p.

Methods for calculating tree biomass are outlined, and the biomass on commercial forest land is estimated for 11 north-central States. Tree biomass in the North Central Region totals 3.6 billion tons, or 50 tons per commercial forest acre. For all species, total tree biomass is concentrated in growing-stock boles.

KEY WORDS: tree weight, tops and limbs, energy.